Flow front tracking in aluminium extrusion dies by means of particle trajectories

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Introduction

Increasingly tighter requirements on complexity and geometric tolerances raise the demand for more insight in the aluminium extrusion process. From the extrusion practise it is known that the startup of the extrusion proces has a great effect on the deformation of the die and therefore a great effect on the performance of the die. An accurate simulation tool for this startup helps the die designer to improve the performance of the dies.

Objective

During the startup of the extrusion process the die fills with aluminium.To keep track of the front of the aluminium flow in a Finite Element simulation with an ALE/Eulerian formulation a function defining this front must be convected.

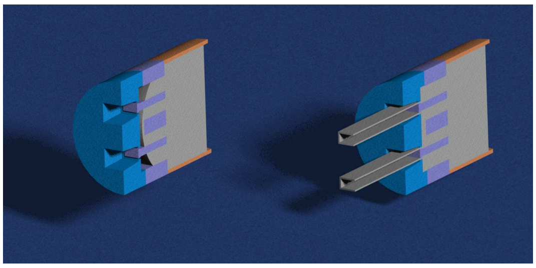

Figure 1 : Filling of an extrusion die

The accuracy of the position of the front is directly related to the accuracy of the convection of the function.

Methods

In 1986 Thompson [1] introduced a pseudo-concentration function $C(X,t)$ to track the flow front. With a value of 0 the material properties should approximate the properties of air and oppositely when the value is equal to 1 the material properties should represent the aluminium. At the front flow the function has a discontinuity. The diffusion neccecary to stabilize oscilations in the convection algorithm, will cause inaccuracy. Choosing a smoother (linear) function to start with, will decrease the error through diffusion. For our calculation we chose the linear original-coordinate function.

Results

The step size of first 1000 steps in figure 2 differ a factor 10 from the last 7000.

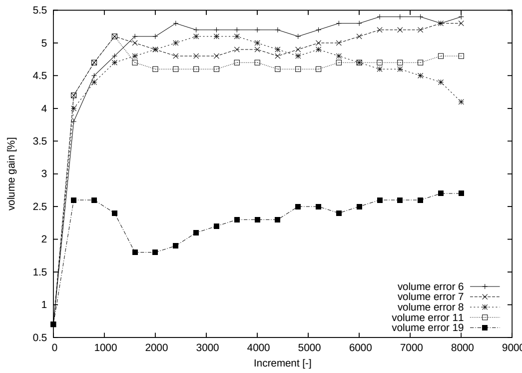

Figure 2 : Error in volume conservation during simulation

A step size dependent error is shown with this figure. In figure 3 the results of simulations are shown at the same step, but with different material properties in the air region.

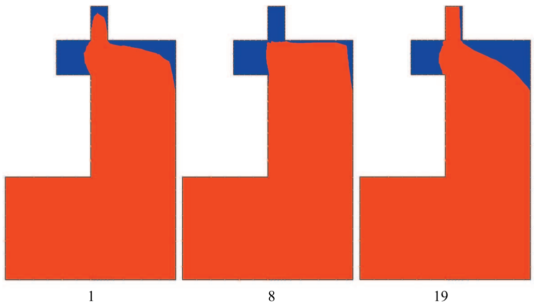

Figure 3 : Shape of the front after 2000 steps

Discussion

2D simulations with a Q4 element and the choice for a smooth, linear function seem to leads to accurate results, however problems arise from the under integration to prevent locking. In the future a higher order T6 element will be tested.

References

1. Thompson, E. (1986). "Use of pseudo-concentrations to follow creeping viscous flows during transient analysis." Int. J. Num. Meth. Fluids 6(10): 749-761.